

THE AIMS OF THE HIGH QUALITY BREEDING PROGRAMME

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The high-quality cotton variety Namcala and its predecessor Hopicala have traditionally been grown on small percentages of the Australian acreage (mainly in NSW) as an alternative to the high yielding varieties such as Deltapine smooth leaf, Deltapine 16 and recently Deltapine 61.

In 6 seasons of large scale CSD trials (data kindly supplied by Richard Lesky) Namcala yielded on average only 91% that of Deltapine 61. As a result of this yield penalty the high-quality proportion of the cotton area since 1969 has been small and usually less than 10% (Figure 1).

In addition to the yield disadvantage, data of the last 5 seasons shows that Namcala consistently has a lower lint percentage and is a half to one grade lower as a result of its hairy leaves and large, fragmentary bracts. Namcala yields tend to fluctuate more than those of DP61 and Namcala is more susceptible to bacterial blight (Figure 2). However, Namcala does produce higher quality lint than the high yielding Deltapine types as measured by the three important fibre characteristics of length, strength and fineness (Stelometer, Pressley and micronaire respectively) (Figure 3). As a result Namcala lint often commands a substantial premium because of its suitability for fine spinning and blending. Another plus is that Namcala has greater tolerance to verticillium wilt which, in certain locations and seasons, can be very damaging.

Although the home consumption of Namcala-type lint is small the overseas market is almost unlimited. The world's spinning industries are currently moving away from traditional ring spinning towards new faster technologies, such as rotor spinning, and these new processes place higher demands on the cotton fibres. The main demand is for higher fibre strength, although length and fineness are also important.

So given all these considerations it was decided two years ago to begin an additional breeding programme at Narrabri to develop a replacement for Namcala. The aim of the programme is to produce varieties with the characteristics laid out in Table 1. These aims are not unique and other

cotton breeders around the world are pursuing a similar goal. However, all these breeders have to cope with one major genetic obstacle, which incidentally occurs with many other crop species; the payoff between quality and quantity. The fibre characteristics strength and length, while being positively correlated themselves, are strongly negatively correlated with the components of yield, particularly lint percentage. The implications of this are that attempts to improve yield tend to lower quality and visa versa. The situation, however, is far from hopeless and the negative association between the genetic control of yield and fibre quality can and is being broken.

The new variety Deltapine 90 goes part-way to this objective since it combines better strength (although well below Namcala) with a high yield. We can learn something from its history. The variety took 19 years to breed (a long time even in plant breeding terms) and was selected from a very unexpected source. These facts indicate that our hybridization work must encompass as large a range of germplasm as possible and that we must handle vast numbers of samples to have a reasonable chance of success. We are utilizing a large range of genetic material as sources of the genes required to synthesise new varieties (Table 3). Our efforts have been made considerably more efficient by the acquisition of a Spinlab High-Volume Quality Testing Machine located at CSIRO Division of Textile Industries, Geelong. While we do not underestimate the task at hand we are confident of success and preliminary results from last season's observation plots are encouraging.

Until a specifically bred high-quality variety is available Dr. Thomson and Mr. Reid have been undertaking intravarietal selection as an interim measure. Their efforts have been rewarded by the isolation of the selection Namcala 830 which has Namcala quality plus improved yield.

As well as our conventional breeding techniques we are experimenting with: a) a number of genetic techniques to speed up the production and isolation of pure breeding lines from segregating material: b) the incorporation of certain species of wild cotton with desirable characteristics into our gene pool: and c) the production of novel genetic variation by chemical and radiation treatment.

In summary we are aiming to create a disease free variety which produces strict middling, 36/32 inch, 105 000 Pressley cotton well before the year 2000.

Table 1

Desirable characteristics of any Namcala replacement variety:

- a) High seed cotton yield and high lint percentage
- b) Bacterial Blight resistance and verticillium wilt tolerance
- c) Smooth to glabrous leaves plus small bracts
- d) Fibre strength, length and fineness of Namcala

Other characters that must be maintained to ensure commercial success:

- e) Seed quality and seedling vigour
- f) Non-lodging and ability of easy defoliation
- g) Maturity equal to or only slightly later than DP 61
- h) Fibre extension (>5%) and uniformity ratio (>45%)

Table 2

The pool of cotton germplasm being used to supply the genes for certain characteristics required in any replacement variety for Namcala. Of course, any promising new material from our own programme or abroad is incorporated as soon as possible.

| <u>Varieties</u> | <u>Origin</u> | <u>Desirable characteristics</u> |
|------------------|---------------|---|
| Tamcot SP37 | USA | Bacterial Blight resistance |
| Albar | Africa } | Bacterial Blight resistance and good quality |
| Reha P279 | Africa } | |
| Namcala | Australia } | Quality and verticillium wilt tolerance |
| Namcala 830 | Australia } | |
| Acala C-1 | USA } | |
| Acala 1517-77 | USA } | |
| Deltapine 61 | USA | Yield |
| SICOT 2 | Australia | Glabrous leaf and stem |
| N74-367 | Australia | Yield, slightly better strength, okra leaf shape, earliness and blight resistance |
| Deltapine 90 | USA | Yield and improved strength |

Figure 1

Percentages of the total Australian cotton acreage sown to the high-quality and the high-yielding type cottons, represented by Hopicala/Namcala and Deltapine SL/DP16/DP61 respectively. Figures are based on seed sales from CSD (data kindly supplied by R.A. Allaway). D (solid line) = Deltapine SL + DP16 + DP61, N (pecked line) = Hopicala + Namcala.

Figure 2

The average lint percentages, seed cotton yields (bales/ha) and grades from large scale CSD trials over a number of seasons for the varieties DP 61 and Namcala. The number of locations contributing to each value varies from 4 to 13 (data kindly supplied by R. Lesky of CSD). D (solid line) = DP61, N (pecked line) = Namcala.

Figure 3

The average Stelometer (32nds inch), Pressley (,000 lbs/sq.inch) and micronaire values from large scale CSD trials over a number of seasons for the varieties DP61 and Namcala. The number of locations contributing to each value varies from 4 to 13 (data kindly supplied by R. Lesky of CSD). D (solid line) = DP61, N (pecked line) = Namcala.

FIGURE 1

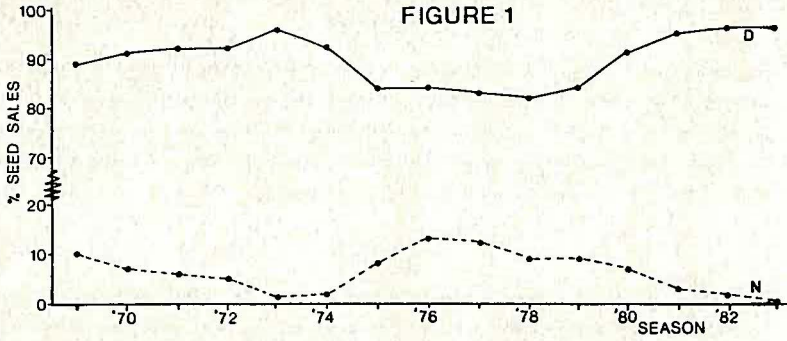


FIGURE 2

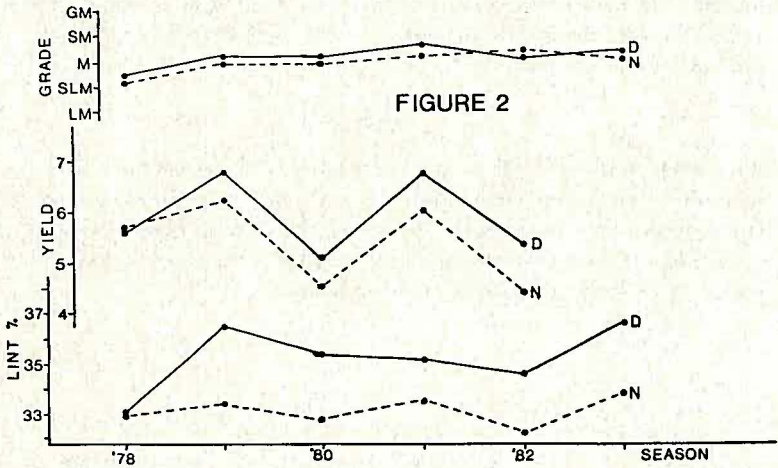
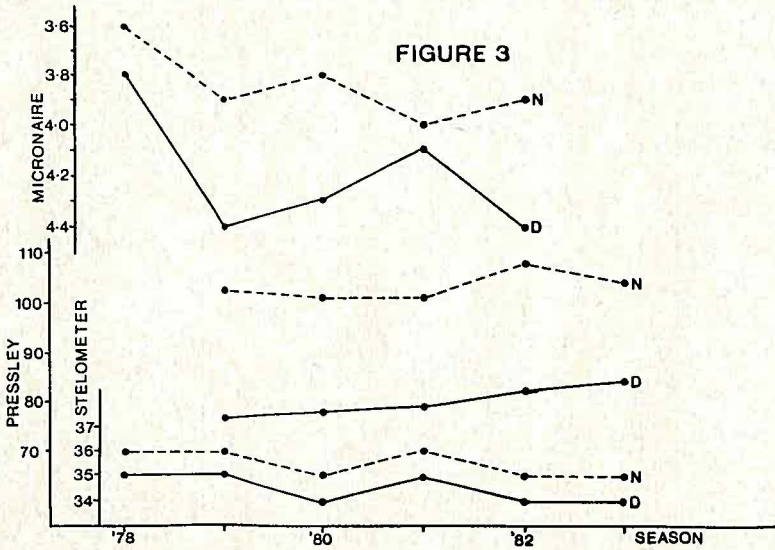


FIGURE 3



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Introduction

Over the last quarter of a century, as problems in relying completely on pesticides for control of insects have become apparent, there has been renewed interest in the possibility of breeding cottons less susceptible to pests i.e. "host plant resistance". This paper describes some of the studies being undertaken at N.A.R.S. on this subject.

Resistant Plant Characteristics and their Pest Effects

A number of plant characteristics affecting insects have been identified by researchers as the following table shows.

Pest-Resistant Plant Characters and Pests Effectuated

| <u>Plant Character</u> | <u>Category of Pests Effectuated</u> |
|--|--|
| <u>Morphological</u> | |
| Pubescence | Plant bugs particularly jassids boll weevil |
| Frego bract | Boll weevil, bollworms |
| Red plant colour | Boll weevil, spidermites |
| Glabrousness | Bollworms |
| Nectarilessness | Plant bugs, bollworms |
| Okra, superokra leaf | White flies, bollworms, weevils, mites |
| Yellow pollen | Bollworms |
| Hard boll wall | Bollworms |
| <u>Phenological</u> | |
| Short season (early maturity) | Boll weevil, bollworms |
| <u>Chemical</u> | |
| High terpenoid (Gossypol, Heliocides) | Plant bug, bollworms |
| Condensed tannins | Plant Bugs, bollworms, spider mites |

Besides earliness, we have mainly been working with the simply inherited characteristics of glabrousness, nectarilessness, frego bract and okra leaf since we saw these as offering the quickest route by which we could provide some "built-in" insect resistance to commercial varieties, before tackling the more complexly-inherited characteristics.

Early observations at Narrabri Agricultural Research Station

Work on host plant resistance has been done for a number of years at NARS. Our first season there co-incided with the Heliothis plague that ravaged crops in eastern Australia. It was significant that, under the heavy damage sustained despite intensive spraying, a normally poor yielding frego bract line topped our main variety trial and outyielded Deltapine 16 by 40%.

In subsequent years a number of varieties containing resistance traits were tested for performance under different levels of pest protection. In general the work showed that the resistance characters often were advantageous, but response differed depending on the particular complexes and pressures of insects encountered. A further difficulty was that the resistance factors were incorporated in a number of varietal backgrounds thus preventing direct comparisons of their effects.

Recent Studies

We incorporated genes for nectarilessness, okra leaf, glabrousness and frego bract into the high yielding Deltapine 61 background. This gave rise to 16 lines only differing in resistance factors from each other as follows:

| | Leaf and Stem Hairiness | Bract Type | Nectary Status | Leaf Type |
|----|-------------------------------|---------------|-------------------|--------------|
| 1 | Normal | Normal | Normal | Normal |
| 2 | " | " | " | Okra |
| 3 | " | " | N'less | Normal |
| 4 | " | " | " | Okra |
| 5 | " | Frego | Normal | Normal |
| 6 | " | " | " | Okra |
| 7 | " | " | N'less | Normal |
| 8 | " | " | " | Okra |
| 9 | Glabrous | Normal | Normal | Normal |
| 10 | " | " | " | Okra |
| 11 | " | " | N'less | Normal |
| 12 | " | " | " | Okra |
| 13 | " | Frego | Normal | Normal |
| 14 | " | " | " | Okra |
| 15 | " | " | N'less | Normal |
| 16 | " | " | " | Okra |

We then grew them for three seasons under two spray regimes - heavy (in which insect control was nearly complete) and light (in which pest control was only intermittent).

Results

The overall mean results for yields combined across genotypes on a with:without character basis are as follows:

Yield of "Pest-Resistant" Types
as % of their NORMAL COUNTERPARTS
MEANS OVER THREE SEASONS

| Character | Spray Regime | | Increase (+) or Decrease (-) (Relative to the normal) under light spraying |
|-------------|--------------|-------|--|
| | Heavy | Light | |
| Okra | 100 | 110 | + 10 |
| Nectariless | 100 | 103 | + 3 |
| Glabrous | 102 | 91 | - 11 |
| Frego | 97 | 92 | - 5 |

Okra leaf showed as being best able to resist the depredations of insects. Nectariless also helped whereas both glabrousness and frego bract gave less yields when insect damage was allowed. It may seem surprising then that we refer to the latter two as "resistant" characters. However almost certainly their poor showing reflects their susceptibility to plant bugs (which tended to be the most important component of the pest spectrum in our trials) whereas their "resistance" refers to their effects on Heliothis.

What happens for various combinations of these factors? There are too many to discuss in this brief account but the following results tell part of the story.

| Characters | Spray Regime | | % Light Heavy |
|----------------------|---------------|-------|------------------|
| | Heavy | Light | |
| | (Yield kg/ha) | | |
| glabrous frego | 1991 | 1712 | 86 |
| + okra | 2010 | 1882 | 94 |
| + okra + nectariless | 1951 | 1958 | 100 |

The bug sensitivity of glabrous frego was largely overcome by okra alone and completely overcome when nectariless was added as well.

Effects on Pests

In 82/83 we recorded the effects of these characters on the abundance of pests. Last season (83/84) the 16 combinations were again grown under the light spray regime and pest numbers recorded.

Some Results

In both seasons about 40% less Heliothis eggs were laid on the glabrous genotypes resulting in about 30% less Heliothis larvae. Less (44% in 82/83 and 20% in 83/84) larvae also occurred on frego bract cotton (although egg numbers were less for this trait only in 83/84). In both seasons a slight (15%) but statistically significant reduction of mites occurred with okra leaf and in 82/83 okra leaf also had significantly less aphids. In both seasons there were about 30% less apple dimpling bugs (small mirids) on glabrous leaf but significantly more on frego bract.

Discussion

We consider that so far we have only touched the "tip of the iceberg" in the complex field of Host Plant Resistance. We do not feel that we can be dogmatic in our views as yet. Both the glabrous and frego genes do appear as Heliothis resistance factors by their effects on egglay and larval numbers: and the frego gene has been shown to improve spray penetration. However their apparent hypersensitivity to the bug complex is a matter of concern, preventing their being used in a simple way to reduce spraying. The okra character appears to "part-neutralize" this sensitivity and the further addition of nectariless appears to do so completely. Even by itself okra leaf does appear to offer considerable advantages - another 'bull point' for SIROKRA!

SHORT SEASON COTTON BREEDING

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Narrabri.

At Narrabri we are continuing our breeding program to develop locally adapted early maturing varieties. At present there are no early varieties available commercially in Australia but we feel that they could play an important role in the following situations:

- (1) In the shorter growing season regions e.g. parts of the Darling Downs and the southernmost N.S.W. areas.
- (2) For late plantings, particularly in southern growing areas. Late planting is often necessary because of poor initial establishment or delayed land preparation through wet weather.
- (3) To enable earlier harvesting. A proportion of early cotton on a farm would spread the risk of encountering weather problems and lessen the pressure on labour and machinery at harvest.
- (4) To offer some escape from insects, particularly a late build up of Heliothis armigera.

Background

Mr. A. Low of CSIRO commenced breeding short-season cotton in the mid 1960's at Griffith in the M.I.A. The region has a short growing season for cotton and varieties of normal maturity were often adversely affected by low temperatures at the beginning and end of the season. Good progress was made in breeding cultivars adapted to the M.I.A. environment but, with the decline of the M.I.A. industry in the early 1970's, CSIRO's short-season breeding program was transferred to Narrabri in the Namoi Valley. Dr. Fred Gillham conducted the program until 1979 when I assumed responsibility for it.

Lines developed at Griffith were tested extensively at Narrabri, and initially further selected. In the longer season environment the M.I.A. material was generally far inferior in yield and staple length to full season cultivars. Most M.I.A. lines also proved to be very susceptible to

Verticillium Wilt and Bacterial Blight.

For the breeding program developed at Narrabri our aims are to produce cultivars which mature about two weeks earlier than the main commercial cultivar Deltapine 61, are competitive in yield, have good fibre quality and are disease resistant. Historically, a major difficulty in breeding for early maturity has been the link between earliness and short staple length and achieving a commercially acceptable staple length of minimally 1 and 1/16 inches is a major consideration.

Progress

We have made considerable progress with the yield, staple length and disease resistance of our short season lines since the early years of the program. Our best lines are much more competitive with full season types and have outyielded U.S.A. varieties of similar maturity. The best yield performances of the early lines have been in late planted trials at Narrabri and in trials conducted on the Darling Downs by the Department of Primary Industries. Over four seasons of mid-November plantings at Narrabri the average yield of 75007-3 (one of our advanced early lines) was 10% greater than Deltapine 61 while in four seasons on the Downs, 75007-3 has averaged 12% better than Deltapine. As expected, under longer growing season conditions Deltapine 61 is superior to our best early lines e.g. at Narrabri in four years of normal planting dates (October) Deltapine has out-yielded 75007-3 by 8%.

When considering other characteristics apart from yield 75007-3 has a number of good features. It is 10 to 14 days earlier to mature than Deltapine, has much better fibre strength and is resistant to Bacterial Blight. Staple length is shorter than Deltapine but it will usually achieve 1 1/16 inches. The main deficiencies of 75007-3 are a low ginning out-turn and hairy leaves which produce lower grades. Newer lines which out performed 75007-3 by up to 8% in three trials last season have smoother leaves and higher out-turns. A greatly expanded selection program is under way with almost 200 promising new selections being tested in replicated trials at Narrabri this season. Our range of sites for testing our early maturity lines has also been expanded to include a site in the Breeza district. This site should prove valuable in selecting varieties suitable for the new marginal cotton areas. Another facet of our work will be an evaluation of some early lines in dryland trials. Although early

varieties have not done well in these trials to date some people feel that they would enable a more stable production system based on low inputs.

Conclusions

While we still have some improvements to make in our early lines in such things as lint percentages, smoother leaves, longer staple and of course greater yields, we are making good progress. We are hopeful that our expanded selection effort will produce even more substantial advances. There is certainly a wide scope for utilization of early maturity in the situations already mentioned and the demand for an early variety could certainly increase substantially if expansion continues in the cooler N.S.W. areas.

COMMERCIAL GROWING OF SICOT 3

N.J. Thomson,
CSIRO Cotton Research Unit.

In 1981 we released SICOT 3 to the industry. This variety is distinguished by glabrous (ultra-smooth) leaves and stems, and frego bracts (these morphological characteristics and their effects on pests are described in another paper - "Host Plant Resistance Studies at Narrabri Research Station by myself, Peter Reid and Gary Fitt). However, besides advantages of Heliothis resistance and fibre quality, these characteristics are associated with less desirable agronomic effects such as increased vegetativeness and delayed maturity. They also appear to be associated with higher sensitivity to some members of the bug complex, further accentuating rankness of growth and delayed maturity if these pests are not controlled.

We and CSD have therefore co-operated in proceeding cautiously with this variety and seed initially was only made available to a few venturesome farmers. This paper reports on some of the results of commercial growing of this variety and discusses ways by which it can be best handled commercially.

80/81 and 81/82 Season

SICOT 3 was grown on five farms over the two seasons in areas ranging in size from 7 to 25 ha. Results that are typical of those recorded for both seasons are shown below:

| Season | Farm | Variety | Yield (b/ac) | Grade % of class: | | | | | Staple | Mike |
|--------|------|---------|-----------------|-------------------|----|----|----|------|--------|------|
| | | | | GM | SM | M+ | M | SLM+ | | |
| 80/81 | 1 | SICOT 3 | 2.45 | 73 | 27 | - | - | - | 1 3/32 | 4.7 |
| | | DP 61 | 2.47 | - | 41 | 55 | 4 | - | 1 3/32 | 5.0 |
| 81/82 | 1 | SICOT 3 | 3.83 | - | 68 | 32 | 1 | - | 1 3/32 | 4.0 |
| | | DP 61 | 3.76 | - | - | 53 | 40 | 7 | 1 1/16 | 4.3 |

SICOT 3 yields were similar to Deltapine 61 with better grades, equal or better length and slightly lower (but always acceptable) micronaire.

82/83 Season

This was a very hot dry season with water shortages occurring during the growing period followed by drenching rains disrupting and delaying harvest. Of the four SICOT 3 growers two reported that it had outyielded Deltapine 61 grown either on the same block or on a comparable adjoining block by 10% although at one farm in Queensland SICOT 3 was classed 1 1/32" cf to Deltapine 1 1/16". On the third farm SICOT 3 yielded 3.89 bales/acre and had 8% more mature bolls just prior to harvest than adjoining Deltapine 61 although a final yield comparison wasn't made. On the remaining farm lack of water prevented a valid comparison but SICOT 3 appeared to suffer more stress than adjoining Deltapine 61.

At least two of the farmers commented that SICOT 3 weathered the heavy rains at harvest better than Deltapine, losing less seed cotton while retaining better quality. They also remarked that SICOT 3's growth habit with the bolls set well clear of the ground was a decided plus in the wet boggy conditions that pertained during harvest.

83/84 Season

Following the successful crops of the previous three seasons some 1000 hectares of SICOT 3 was grown by fourteen producers. Most was grown in the Namoi Valley or nearby Moomin Creek area and a block was also grown at Emerald.

The season was wet and very cool - coolest recorded in the last 24 years at Narrabri Research Station. It was feared that SICOT 3 would perform poorly under these conditions. Yet in many cases good yields (relative to Deltapine 61) were obtained. In an effort to see whether any practices contributing to success or failure with the variety could be found, growers were invited by a questionnaire to report on SICOT 3's performance as compared to similarly managed Deltapine 61. Besides yield and quality, information was obtained on sowing date and sowing rate, previous crop, fertilization, irrigation, waterlogging, number of sprays and their general timing. Replies were received from all except a couple of producers.

Three categories of yield were apparent: (i) the majority (9) where yields were better than Deltapine's by as much as 16% (ii) a small group of 2 whose yields were slightly less than Deltapine and (iii) a small group of 3 with yields about 25% less. Other general features were that SICOT 3 on almost every farm had almost a full grade advantage. Staple length was generally similar except in a few cases where SICOT 3 recorded shorter staple. On average differences in micronaire were small although at the individual farms considerable variations were often apparent.

Relationship of Agronomic Practices to Yield Differences between Deltapine 61 and SICOT 3

Associations between agronomic practices and yield of SICOT 3 relative to Deltapine 61's yield were examined. Generally SICOT 3 responded favourably to early sowing: to land previously cropped to cotton (rather than fallow): to stringent pest control: and to frequent irrigations. SICOT 3 crops grown under these conditions then benefited more than Deltapine 61 from applications of foliar nitrogen. High yielding SICOT 3 crops were also quicker setting and matured earlier than low yielding crops.

I personally inspected all the Namoi crops during the season and visually such differences were also obvious. The three crops that "went badly wrong" were all grown on fallow land and during growth they appeared "nitrogen rich". All suffered severe tipworm damage so that they went into a cool wet January without any developing bolls to restrict growth. Thus by February they were rank and tall before setting a heavy crop during that month and March. However any chance for these late-set crops was "nipped in the boll" by the frosts of early May: and their huge potential remained unrealized.

Summary and Conclusions

In all, our total experience demonstrates that SICOT 3 is more sensitive or less robust i.e. less buffered than Deltapine 61 to environmental hazards. On the other hand it also appears that SICOT 3 has the potential to outyield Deltapine 61. To reduce the risk involved with growing this variety, and to realize as much of its potential as possible, it is advisable to:

- (1) Plant as early as possible.
- (2) Restrict early growth by planting on land with low levels of immediately available nitrogen.
- (3) Pay strict attention to control of sap-sucking pests.
- (4) Once the crop is fruiting ensure that water and nitrogen are not limiting.
- (5) Be prepared to wait if necessary for the crop to mature before defoliation and picking.

It should be clear that SICOT 3 is not an all-purpose variety and no grower should attempt growing it until he is sure he can meet its particular requirements. It would also seem wise that no grower commit too high a proportion of his cotton growing area to it since it is not always possible to manage crops as well as might be planned. However should heavy Heliothis pressure be encountered I feel that SICOT 3, with the advantages conferred by its glabrous leaf and frego bract, will have a better chance of "riding the storm" than conventional hair and bract varieties and this is surely also an important consideration for all producers.

Acknowledgements

I thank all the SICOT 3 growers who generously gave of their time to work out the detailed answers to the questionnaire and to their helpful comments.